PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 4 : A23L 1/015, 1/20, A23J 3/00 — A1

(11) International Publication Number: WO 86/ 05659

(43) International Publication Date: 9 October 1986 (09.10.86)

(21) International Application Number: PCT/US86/00521

(22) International Filing Date: 18 March 1986 (18.03.86)

(31) Priority Application Number: 477,902

(32) Priority Date: 29 March 1985 (29.03.85)

(33) Priority Country: CA

(71) Applicant: GUPTA, Mahendra, Prasad [US/US]; 12732 Glenage Drive, Maryland Hights, MO 63043 (US).

(72) Inventors: GUPTA, Ragendra, Prasad ; GUPTA, Rashmi, R. ; 627 Gaines Drive, Gloucester (Ottawa), Ontario K1J 7W7 (CA).

(74) Agents: NORRIS, Jerome, J. et al.; 2001 Jefferson Davis Highway, Arlington, VA 22202 (US).

(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FR (European patent), GB (European patent), IT (European patent), JP, LK, LU (European patent), NL (European patent), SE (European patent).

Published
With international search report.

(54) Title: FOOD PROCESSING IN OXYGEN-FREE ENVIRONMENT

(57) Abstract

Processing of plant seeds for foods, food ingredients and edible oils such that the end products do not have undesirable flavors or taste. The prior art methods for effective elimination or reduction of off-flavors that develop in foods, such as proteins and oils, are not very compatible with the preparation of their highly functional or desirable forms because they require conditions that cause denaturing of the foods. A method is disclosed which permits food processing with minimum denaturing while preventing development of off-flavors. The key element of the method comprises disintegrating seeds and then further processing the resulting mass sufficiently to inactivate lipoxygenase enzyme, such as by heating, in an oxygen-free environment. The disclosed applications include processing of legumes, nuts and other protein and oil bearing seeds into bland products like protein concentrates, protein isolates and edible oils. When applied to the processing of soybeans into artificial milk, the method produced high yield of soymilk which had no characteristic beany off-flavor, throat catching sensation or chalk-like mouth feel.

BEST AVAILABLE COPY

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GA	Gabon	MR	Mauritania
AU	Australia	GB	United Kingdom	MW	Malawi
BB	Barbados	HU	Hungary	NL	Netherlands
BE	Belgium	IT	Italy	NO	Norway
BG	Bulgaria	JP	Japan	RO	Romania
BR	Brazil	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic			SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LI	Liechtenstein	SU	Soviet Union
CM	Cameroon	LK	Sri Lanka	TD	Chad
DE	Germany, Federal Republic of	LU	Luxembourg	TG	Togo
DK	Denmark	MC	Monaco	US	United States of America
FI	Finland	MG	Madagascar		
FR	France	ML	Mali		

FOOD PROCESSING IN OXYGEN-FREE ENVIRONMENT

FIELD OF THE INVENTION

This invention concerns the processing of plant seeds for foods, food ingredients and edible oils which have no undesirable flavor or taste. More specifically, this invention relates to the method of preparing foods and beverages and extracting oils without off-flavors from soybeans and other legumes.

BACKGROUND OF THE INVENTION

To be generally acceptable the foods, which definition here will include food ingredients and edible oils, need not only be nutritious, versatile and economical, but also be attractive in color, aroma, taste and texture. Plant protein preparations mainly from legumes and nuts, like soybeans, have unacceptable off-flavors which score heavily against their positive properties and limit their use.

Lipoxygenase enzyme has been recognized as the major cause of off-flavors in most vegetable proteins sources including soybeans, peas and peanuts. Polyunsaturated fatty acids are oxidized through the catalytic action of lipoxygenase to initially produce hydroperoxides and finally yielding off-flavor causing agents like aldehydes, ketones, alcohols, furans, alpha-ketols and hydroxyacids.

Lipoxygenase is distributed throughout the cotyledons in legumes and many other seeds, but the enzyme is inactive because of its limited contact with oxygen and the substrate which are immobile due to the plants cell structure. Breaking of cell structure during the size reduction operation causes the oxidation to proceed. The control of off-flavors, therefore, requires inactivation of lipoxygenase enzyme.

Since lipoxygenase is heat sensitive, its inactivation is most commonly accomplished by thermal processing. At temperatures above 60°C. the half-lives of the various lipoxygenase enzymes rapidly decrease with increasing temperature. However, heat treatment

also reduces the nitrogen solubility index and protein dispersibility index. The currently available methods for the effective elimination or reduction of off-flavors in plant proteins are not very compatible with the preparation of their highly functional forms because they require conditions that cause denaturing of the proteins. Also, the removal of off-flavors in edible oils not only makes the oil refining process complex but also causes oil degradation. A method is needed to solve these problems in a natural and simple way.

DESCRIPTION OF THE PRIOR ART

Many methods for the processing of legumes and other protein and oil bearing seeds have been proposed which alleviate the off-flavor problems in the end food products; examples are Canadian Patents: 396108 issued to E.C. Winkler and H. Goller on January 16, 1933; 457603 issued to R.A. Wait on November 9, 1938; 675029 issued to T.W.M. Paulsen on November 26, 1963; 677452 issued to R.J. Moshy on January 7, 1964; 819072 issued to K. Fujita et al, on July 29, 1969; 920869 issued to J.R. Wagner on February 13, 1973; 1004531 issued to A.I. Nelson et al, on February 1, 1977; 1083879 issued to D.S. Hsieh et al, on August 19, 1980; and 1091081 issued to T. Wakana et al, on December 9, 1980.

The flavor problems in soybean proteins have been reviewed by J.E. Kinsella and S. Damodaran in a book "The Analysis and Control of Less Desirable Flavors in Foods and Beverages" edited by G. Charalambous and published by Academic Press in 1980. F.D. Gunstone and F.A. Norris in their book "Lipids in Foods: Chemistry, Biochemistry and Technology" published by Pergamon Press in 1983, have discussed the off-flavor problems in edible oils and methods for solving them. The prior art methods either try to inactivate the enzymes, such as lipoxygenase, involved in producing off-flavors, prior to seed desizing and deforming operations, or remove off-flavors as much as possible after they have devel-

oped. Both the approaches tend to degrade the end product nutritionally, functionally or otherwise. For example, low or no beany flavor soymilks prepared with prior art processes give chalk-like mouth feel due to undesolved fine particles in the milks remaining even after intense high pressure homogenization. The problem generally results from the heat treatment of soybeans to inactivate lipoxygenase enzyme prior to or during the disintegration of soybeans in aqueous media. Such heat treatment adversely effects the protein dispersibility index, which in turn adversely effects the soymilk yield.

The method of the present invention eliminates the off-flavor problem without adversely effecting the quality or yield of the end product.

SUMMARY OF THE INVENTION

One objective of this invention is to provide a method of processing legumes and other seeds into foods having no off-flavor or undesirable taste but without adversely effecting nutritional quality and functionality of the end food products. Another objective is to apply the invention method to producing soymilk with high yield and nutritional quality but without beany off-flavors and chalky mouth-feel. The present invention has established that off-flavors can be prevented from developing if size reduction and additional processing, until lipoxygenase enzyme is inactivated, is carried out in an oxygen-free environment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention concerns processing of legumes and the like protein and oil-rich seeds with minimal denaturing to obtain end food products without undesirable flavors. The process comprises disintegration and deforming of the seeds, such as by grinding, milling and flaking, and further processing of the seeds up to and including the stage at which at least one of

the seed member essential for reactions producing volatiles in off-flavors, such as lipoxygenase enzyme and lipids, is either inactivated or removed, in an environment deprived of most free oxygen, the latter being also an essential member in the said reaction. Since lipoxygenase catalyses the oxidation of lipids to produce off-flavor causing volatiles, one effective means of controlling off-flavors will be to desize the seeds into flakes, extract the seed oil by the solvent extraction process, and heat treat the oil to inactive lypoxygenase, in oxygenless environment. The edible oil thus extracted will be free from most off-flavors. Also, lipoxygenase in the deoiled seed flakes cannot be active since there are hardly any lipids left in the said flakes, especially on the surface where oxygen from air contacts said flakes. Thus, foods made from the said flakes with prior art methods will have little or no off-flavors. However, for best results it may be desirable to process said flakes up to and including the stage of cooking in oxygen-free environment.

Since flavor threshold may vary from below 0.1 ppm to above 100 ppm depending on the volatile causing an off-flavor and the substrate it is in, what is oxygen-free environment for one volatile and substrate combination may not be true for another such combination. However, as a rule of thumb, total oxygen presence in the substrate and the environment said substrate sits in should not exceed the flavor threshold of the off-flavor desired to be controlled.

One of the more common use of this invention is expected in processing soybeans to extract oil and to prepare artificial milk, protein concentrates, protein isolates and the like, which are free from the characteristic soybean off-flavors and throat catching sensation.

In the following, the term aqueous medium will be used for drinkable water as well as for dilute aqueous

solution of acid, alkali or salt, while the term vacuum will be used for pressures low enough to effect boiling of the aqueous medium without heating the same. The vacuum so defined causes release of most oxygen dissolved in water and replacement of residual air in the evacuated environment by water vapors.

The following processes illustrate the application of the invention to soybeans processing:

1. One embodiment of the method comprises soaking soybeans in an aqueous medium, rinsing the swelled soybeans, putting said soybeans and an aqueous medium in a container, creating vacuum in said container, disintegrating said soybeans in said container, isolating the said container from the device used to create vacuum, heating the resulting slurry in said container sufficiently to inactivate lipoxygenase enzyme and trypsin inhibitor, and removing undesolved solids from the cooked slurry to obtain soybean milk having good taste and mouth-feel but without off-flavors and throat catching sensation. Trypsin inhibitors are heat sensitive substance in soybeans which inhibit growth in growing animals and can cause pancreas enlargement and must be adequately inactivated in an edible product. Since soybeans are disintegrated at room temperatures, which results in high protein solubility in aqueous media, the process yields soybean milk which is remarkably close to dairy milk in mouth-feel.

2. Another embodiment of the method comprises soaking soybeans in an aqueous medium, rinsing the swelled soybeans, putting the said soybeans with an aqueous medium, to which a deoxygenating agent like sodium sulfite may have been added, in a closed container with a small vent tube at the top, filling it with said aqueous medium such that no air bubble is trapped in the container and thereby establishing an oxygenless-environment, cooking the resulting slurry

in said container to inactivate lipoxygenase enzyme and trypsin inhibitor, and straining the cooked slurry to obtain soybean milk having good tase and mouth feel and acceptable flavor.

3. Another embodiment of the method comprises processing soybeans as in Embodiment 1 excepting flushing the vacuum with nitrogen gas.

4. Another embodiment of the method comprises processing soybeans as in Embodiment 3, excepting that the soaking of soybeans is also done in a container evacuated and flushed with nitrogen gas.

5. Another embodiment of the method comprises splitting and flaking dehulled soybeans, extracting oil from the soybean flakes by the solvent extraction process, flash desolventizing said flakes, heating the extracted oil sufficiently to inactivate lipoxygenase enzyme, and further processing the deoiled flakes to obtain various protein foods up to and including the stage of cooking, in vacuum or an inert gas environment. The resulting end products are free from undesirable flavors or taste.

6. Yet another embodiment of the invention method comprises splitting and flaking dehulled soybeans, extracting oil from the soybean flakes by the solvent extraction process, flash desolventizing said flakes, and heating the extracted oil sufficiently to inactivate lipoxygenase enzyme, in vacuum or an inert gas environment. The deoiled soybean flakes are exposed to air and kept under atmospheric conditions in the usual way until further processed. Because of the absence of lipids on soybean flake cells exposed to air, lipoxygenase remains inactive as in whole soybeans. Depending on the residual oil in said soybean flakes and the off-flavor level acceptable in the end products, it may or may not be necessary to process said flakes to make artificial milk, protein concentrate, protein isolates, or the like, in oxygen-free environment.

This invention is further illustrated by the follwing examples:

EXAMPLE 1.

75 g of whole soybeans were soaked in tap water at room temperature for ten hours. The swelled soybeans were rinsed twice with water and put with 500 ml water in the so called one quart stainless steel container of a Warring Commercial Blendor. The container was appropriately modified to stand high vacuum even when in blending operation. A vacuum good enough to effect boiling of water at room temperature was created in the container using a vacuum pump capable of pumping down to 25 micrometre Hg pressure; water boils at 17 mm Hg pressure at 20°C. The water was allowed to boil for a few minutes to effect water degassing and to replace residual air in the container with water vapors. The container was then isolated from the vacuum pump so that accessive foaming may not occur when the soybeans are disintegrated. The blender was run for 30 seconds and the container was put in a boiling water bath for 20 minutes to inactivate lipoxygenase enzyme. The container was then opened to atmosphere and the soybean slurry transferred to a pressure cooker and the slurry cooked for a few minutes at 15 p.s.i. pressure to inactivate trypsin inhibitor. Finally, the soymilk was extracted by straining the slurry through a cloth and mechanically squeezing the fibrous residue. About 600 ml soymilk was obtained that had no off-flavor or bad taste.

EXAMPLE 2.

150 g of whole soybeans were soaked in tap water at room temperature for ten hours. The swelled soybeans were rinsed twice with water and put in the container of Example 1. The container was filled with water to the top and closed with a custom made air tight transparent lid provided with a vent tube of small diameter. It was made sure that there were no water bubbles entrapped in the container. The blender was run for about one minute

to disintegrate soybeans. The container was then put in a boiling water bath for 30 minutes to inactivate lipoxygenase enzyme. The container was opened and the slurry transferred to a pressure cooker and the slurry cooked for a few minutes at 15 p.s.i. pressure to inactivate trypsin inhibitor. Finally, soymilk was extracted by straining the slurry through a cloth and mechanically squeezing the fibrous residue. Soymilk was similar to that of Example 1 excepting that a very low beany flavor was detectable upon refrigeration.

EXAMPLE 3.

Example 1 was repeated excepting that 500 ml of 0.1% sodium bicarbonate solution was used in place of water when placing soybean in the container. The soymilk obtained had no off-flavor or bad taste but had slightly more color than that of Example 1.

EXAMPLE 4.

Example 2 was repeated excepting that about 100 miligrams of sodium sulfite was added to the contents of the container to deoxygenate water. The soymilk thus obtained was not significantly better than that of Example 2.

EXAMPLE 5.

Example 1 was repeated with vacuum flushed with nitrogen gas at about atmospheric pressure. The soymilk obtained was similar to that in Example 1.

All the soymilks of Example 1 to 5 gave mouth-feel similar to that of dairy milk. Soymilk flavor or taste was easily possible to enhance or change by adding sugar, common salt, flavors, colors and the like.

Since many apparently widely different embodiments of this invention could be made without departing from the scope and spirit thereof, it is intended that all matter contained in the above description be interpreted as being illustrative only and not limiting.

The embodiments of the inventionin which an exclusive property or privilege is claimed are defined as follows:

1. A method for preparing protein foods without the characteristic off-flavors or bitter taste from legumes and other protein containing seeds comprising:
i) size reduction of said seeds in an oxygen-free environment that may be partially or fully an aqueous medium comprising of drinkable water or dilute aqueous solution of an acid, alkali or salt; and,
ii) further processing the resulting mass sufficiently to inactivate lipoxygenase enzyme, such as by heating, in said environment.

2. A method of extracting edible oil and preparing foods without the characteristic off-flavors or bitter taste from legumes and other seeds comprising:
i) flaking of said seeds in an oxygen-free environment;
ii) desolving oils from seed flakes in an organic solvent in said environment;
iii) recovering the desolved oil from said solvent in said environment;
iv) heat treating said oil to inactivate lipoxygenase enzyme in said environment;
v) flash desolventizing the deoiled flakes in said environment; and,
vi) processing said flakes into artificial milk, protein concentrates, protein isolates, or the like, up to and including the stage of cooking in said environment.

3. A method as defined in Claim 2 wherein the flash desolventized flakes are exposed to air for selling, moving, storage, or the like, and processing said flakes into artificial milk, protein concentrates, protein isolates, or the like, up to and including the stage of cooking, in an oxygen-free or oxygen containing environment.

4. A method of preparing defatted flakes, meals, flour and the like foods with little or no characteristic off-flavors or bitter taste from legumes and other seeds

comprising:

i) preparing flash desolventized flakes as defined in Claim 2 in oxygen-free or oxygen containing environment;

ii) optionally heating said flakes to inactivate lipoxygenase enzyme in said environment; and

iii) disintegrating said flakes in said environment.

INTERNATIONAL SEARCH REPORT

International Application No PCT/US86/00521

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4): A23L 1/015, 1/20; A23J 3/00

U.S. Cl. 426/629

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.	426/312, 319, 629, 634, 656, 417, 430, 489, 518

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
A	US, A, 2,524,991, Published 10 October 1950 Renner	1-4
X	US, A, 4,369,198, Published 18 January 1983 Uchi et al	1
X	US, A, 4,209,541, Published 24 June 1980 Clatfelter et al	1-4

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
04 May 1986	09 MAY 1986
International Searching Authority [1]	**Signature of Authorized Officer [20]**
ISA/US	Robert A. Yoncoskie Robert A. Yoncoskie

Form PCT/ISA/210 (second sheet) (October 1981)

BEST AVAILABLE COPY